SEAMLESS REDUNDANT ECHO CANCELLER REPLACEMENT IN A MULTI-CHANNEL ECHO CANCELLER

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Field of the Invention

The present invention is directed to echo cancellers used in telecommunications systems. In particular, the invention relates to a system for replacing a first multi-channel echo canceller with a second multi-channel echo canceller during operation of the telecommunication system.

Background

Echo in telecommunications systems may arise from impedance matches at a four-wire to two-wire hybrid interface, or from an acoustic feedback path at one end of a call. Echo cancellers are essential to long-distance telephonic communication in order to obtain intelligible full-duplex calls. An echo canceller operates by developing an impulse response model of the echo path, and then generating and subtracting an estimated echo signal from an outbound signal on the basis of the impulse response model and the inbound signal. Because an echo canceller alters the outbound telecommunication signal, it is desirable to disable echo cancellation for certain calls, such as data communication calls, and to enable echo cancellation for voice communication calls. One such method of selectively enabling or disabling echo cancellation is to transmit standardized control tones along the telecommunication path. Echo cancellers responsive to such control tones then enable or disable echo cancellation accordingly. In a time-division

multiplexed communication system, a single echo canceller module may provide echo cancellation for several channels on a time-division processing basis. Hence, in addition to developing an impulse response model for each of the channels in which echo cancellation is enabled, a multi-channel echo canceller also maintains state information for each channel, indicated whether echo cancellation is enabled.

During the course of operation of a telecommunication system, it may be necessary to take an echo canceller out of active service. For example, an echo canceller may fail, or it may be desirable to upgrade or otherwise service an echo canceller. Because active telephone calls may be in the course of transmission at the time an echo canceller is taken out of service, it is desirable to provide a method in which an active echo canceller may be replaced by another echo canceller without interrupting call transmission. In the case of a multi-channel echo canceller, it would also be desirable for the replacement echo canceller to obtain the current state information indicating the status of echo cancellation for each channel.

Summary

In accordance with the present invention, an apparatus and method for replacing an active echo canceller with a redundant echo canceller during operation of a telecommunication network is provided. The active echo canceller is configured to generate signals indicating the current status of echo cancellation on each of a plurality of telecommunication channels within a multiplexed telecommunication signal. A system controller is connected with the active echo canceller and with the redundant echo canceller. The system controller receives the status signals from the active echo canceller and stores the current state of the

active echo canceller. The system controller is further configured to route an inbound telecommunication signal to the active echo canceller and/or to the redundant echo canceller, and to select a processed signal from either echo canceller for outbound transmission thereof. When the system controller operates to switch the outbound signal from the active echo canceller to the redundant echo canceller, the system controller transmits the present status information to the redundant echo canceller in order to place the redundant echo canceller into the same state as the active echo canceller. Then, the system controller switches the output signal of the redundant echo canceller to the outbound telecommunication signal at a subsequent TDM frame edge.

Brief Description of the Drawings

The foregoing Summary and the following Detailed Description will be best understood in connection with the attached drawings in which:

FIG. 1 is a functional block diagram of a system for activating a redundant echo canceller during operation of a primary echo canceller; and

FIG. 2 is a functional block diagram of an echo canceller unit of the system of FIG. 1.

Detailed Description

Referring now to FIG. 1, there is shown an arrangement for replacing an active echo canceller with a redundant echo canceller. An input telecommunication signals, such as an E1 32-channel PCM multiplexed signal, is received by a system controller 10 along input line 12, and is processed for echo cancellation. The processed signal is transmitted from the system controller along

line 14. During normal operation of a primary echo canceller module 16, the system controller 10 routes the inbound PCM signal to the echo canceller module 16 and receives the processed PCM signal from the echo canceller module 16 along line 18. Control signals between the system controller 10 and the echo canceller module 16 are communicated along line 20.

The echo canceller module 16 includes a system interface 22 for receiving and transmitting respective PCM and control signals to and from the system controller 10, an echo logic interface 24, an echo canceller unit 26 implemented as an application-specific integrated circuit (ASIC), and a CPU 28 for coordinating the functions of the echo canceller module 16.

The echo canceller unit 26 is shown in greater detail in FIG. 2. In a preferred embodiment, the echo canceller unit 26 is configured for processing a 32 channel outbound signal, received at send-in terminal SI. The processed signal is provided at send-out terminal SO. The inbound telecommunication signal is received at receive-in terminal RI, and passed to a receive-out terminal RO. A tone-disabler circuit 60 is connected with the RO terminal and is configured for detecting an echo canceller disabling tone in any of the 32 telecommunication channels. The tone-disabler circuit maintains a 32 bit status register for storing the current echo cancellation status (enabled or disabled) for each of the channels. The tone-disabler circuit 60 continuously transmits the contents of its status register as a serial signal via a tone-disable bypass signal terminal (TD_Bypass). Each PCM data channel for which echo cancellation is disabled passes from the SI terminal through a send path bypass register 62 to a multiplexer 64. Each PCM data channel for which echo cancellation is enabled passes from the SI terminal

through echo filter 64, and then to multiplexer 64. The signals provided to multiplexer 64 are arranged in proper time-division sequence, and then provided at the SO terminal. An Overall Bypass terminal is provided for receiving an external serial signal effective to bypass echo cancellation within the echo canceller unit 26. The Overall Bypass signal controls operation of the multiplexer 64 in order to select the unprocessed send-input signal or the echo canceled signal, and to pass the selected signal to the SO terminal.

Referring again to FIG. 1, the echo logic interface 24 is configured to receive the TD_Bypass signal from the echo canceller unit 26 and store the TD_Bypass signal in an internal 32 bit register. The echo logic signal produces the Overall Bypass signal by performing a logical OR upon the received TD_Bypass signal, and an alternative bypass signal generated by CPU 28. The Overall Bypass signal is clocked to the echo canceller unit 26 at the channel time-division rate. In this manner, echo cancellation on each of the channels is determined by the TD_Bypass signal and by the alternative bypass signal, so that the CPU 28 can direct that echo cancellation be disabled on any channel independently of the tone disabler circuit of the echo canceller unit.

During operation of the echo canceller module 16, the CPU 28 maintains a record of the echo cancellation status of each channel. Whenever the echo cancellation status of a channel is changed, the CPU 28 transmits a message to the system controller, via system interface 22, indicating such a change, so that the system controller 10 maintains an independent record of the present state of echo cancellation on each channel.

The system controller 10 may be configured to detect a fault in the

operation of echo canceller module 16 and to replace echo canceller module 16 with a redundant echo canceller 36. Additionally the system controller 10 may perform replacement of the echo canceller module 16 in response to an external signal received along control line 31. The redundant echo canceller module 36 is connected to the system controller 10 via PCM communication line 34 and data communication line 32. The redundant echo canceller module 36 is similarly configured as echo canceller module 16. When the system controller 10, whether independently or in response to an external control signal, initiates replacement of module 16 with module 36, the system controller maintains transmission of the PCM and control data to the module 16, and begins to transmit the same PCM and control data to module 36 in parallel. This parallel transmission may commence asynchronously with the transmission frame timing of the E1 PCM signal, and allows the module 36 to initialize and stabilize. Additionally, the present status of echo cancellation enablement, as stored by the system controller is transmitted to the redundant module 36 and written into the status register of the echo logic interface of the redundant module. At the next frame edge of the E1 PCM signal, or at a subsequent frame edge, the system controller 10 internally switches the outbound PCM signal line 14 to transmit the processed PCM signal from the redundant echo canceller 36. In this manner, the redundant echo canceller 36 is brought into operation having the same echo cancellation status as was present on each channel in the primary echo canceller 16 at the time that a replacement condition was indicated.

It will be appreciated that additional information pertaining to the operation of the primary echo canceller can be monitored by the CPU thereof,

transmitted to the system controller 10 during operation, and used to initialize operation of the redundant echo canceller 36. The method described above provides for bringing a redundant echo canceller 36 online while preserving the cancellation status of each channel. In a further adaptation of this method, the CPU of the active echo canceller may be configured to receive other state information from the echo canceller ASIC thereof. For example, the echo canceller ASIC may be configured to perform additional or alternative signal processing operations such as audio enhancement, code conversion, compression, and the like. In such an embodiment, the CPU may monitor and transmit to the system controller, the present status of such additional or alternative signal processing operations. Hence, it will be appreciated that echo cancellation, as discussed above, is but one of a variety of signal processing operations that may be performed on the telecommunication signal channels. Furthermore, the CPU of the echo canceller unit 16 may monitor and transmit to the system controller such additional state information as the present state variables defining the impulse response and/or time delay parameters utilized to perform echo cancellation within each channel. In this manner, the redundant echo canceller may be activated and brought online with no adaptation delay required to obtain accurate echo cancellation within each presently operating channel of the telecommunication signal.